U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 74-9-271

WHEELING PITTSBURGH STEEL CORPORATION
STEUBENVILLE, OHIO

MARCH 1976

I. TOXICITY DETERMINATION

It has been determined that cast floor-blast furnace workers are exposed to potentially toxic concentrations of respirable free silica. It has also been determined that on occasion stockhouse blast furnace workers may be exposed to potentially toxic concentrations of respirable free silica. This determination is based upon the findings of excessive concentrations of free silica in the work environment in a study conducted April 29-May 1, 1975 and the recommended environmental standard of the NIOSH Criteria Document for occupational exposure to crystalline silica (free silica). Specific environmental and medical control recommendations have been made in the body of this report.

It has also been determined that potentially toxic exposures did not exist on the day of evaluation (April 25, 1974) to the crane operator in the stripper building from exposure to iron oxide fume, carbon monoxide, and free silica or to maintenance workers in the 44" soaking pit area from exposure to sulfur dioxide and carbon monoxide. Detectable levels of carbon monoxide, sulfur dioxide, and iron oxide fume were not measured while the free silica level was less than 0.4 of the Federal Standard.

II. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202.

Copies have been sent to:

a) Wheeling-Pittsburgh Steel Co., Steubenville, Ohio

b) Authorized Representative of Employees

c) U.S. Department of Labor - Region V

d) NIOSH - Region V

For the purposes of informing the approximately 500 "affected employees" the employer shall promptly "post" the Determination Report in a prominent place(s) near where exposed employees work for period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669 (a)(6) authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received such a request from an authorized representative of employees regarding employee exposure to coal tar pitch, iron oxide, carbon monoxide, silica, graphite, manganese, calcium oxide, and dust. The areas of the plant specifically included in the request were the 80" mill, 44" soaking pits, stripper building, and the blast furnace area.

A final report was issued in February, 1975 based upon the findings of an investigation conducted in April, 1974. An official of the Wheeling-Pittsburgh Steel Corporation raised objections to the findings in that report primarily based upon the sampling and analytical methods used to evaluate free silica exposure of workers in the blast furnace area of the plant. Accordingly it was agreed to reactivate this Health Hazard Evaluation in order to develop sufficient data to determine whether or not a potential health hazard may exist to workers from exposure to free silica in the blast furnace area.

IV. HEALTH HAZARD EVALUATION

A. Plant Process

This mill manufactures iron and steel as well as hot and cold rolled steel. The eighty inch rolling mill area was visited and production workers were observed to spend most of their shifts inside control rooms. One man is required to work for extended periods on the operating floor cutting up steel scrap. This work practice had been evaluated by air sampling during a previous OSHA inspection and was not evaluated again by the NIOSH team. Some recommendations were made for improvement of industrial hygiene conditions during the tour.

Cranes are used in the stripper building to remove molds from ingots. One or two crane operators may work in this area. Observation indicated a potential for some exposure to iron oxide for these workers. The forty-four inch soaking pit area was toured with little potential exposure judged for the operators since they spend most of the shift in control rooms. Maintenance workers do work in the mill area and could possibly be exposed to gases from combustion especially sulfur dioxide and carbon monoxide.

The blast furnace area was the last area visited and some potential exposures to several substances were observed. The crew responsible for tapping the furnace has the greatest chronic exposure to several substances including iron oxide fume, graphite, sulfur dioxide, and free silica. The larry car operators working in the stockhouse may be exposed to dusts from several substances including iron ore, calcium carbonate, and coke.

B. Evaluation Design

Those operations which were judged to have the greatest potential for worker exposure were evaluated where possible with personal breathing zone samples. The two crane operators' exposures were evaluated for iron oxide, and several workers in the blast furnace and stockhouse area were evaluated with breathing zone samples to determine the exposure to free silica. The soaking pit area was monitored with detector tubes to measure carbon monoxide and sulfur dioxide levels to which maintenance workers were exposed. Worker exposure to coal tar pitch volatiles was not evaluated since the only identified source of coal tar pitch volatiles was located at another plant not subject to this request. Exposure to manganese and graphite were not evaluated since blast furnace workers were potentially exposed simultaneously to graphite, manganese, and silica. Silica was selected for evaluation since it was considered to create the greatest potential for health hazard to the workers involved. It was also judged that the use of multiple sampling devices on these workers might impede the use of safety clothing and equipment.

Exposure to calcium oxide dust involved very brief intermittent exposures. The area of use was inspected by the NIOSH investigators, but the actual use of calcium oxide was not observed during the evaluation.

C. Evaluation Methods

April, 1974 Study

Samples of iron oxide and free silica were obtained using personal air sampling equipment. Total dust samples were obtained using closed faced three-piece cassettes containing the filter media while respirable dust samples were obtained using a 10 mm cyclone in series with the filter media. Total weight gain of filters was determined gravimetrically. Iron was measured by atomic absorption spectrometry,[1] and silica content of dust was determined using a colorimetric method.[2]

April - May, 1975 Study

Personal samples for evaluating exposure to free silica were obtained with a 10 mm nylon cyclone as a size selector using a polyvinyl chloride filter of 5.0μ average pore size to collect the fraction of respirable dust passing the size selector. These filters were analyzed for free silica by an x-ray diffraction analytical technique.[3]

Respirable area samples were obtained in the cast floor and stockhouse areas utilizing a 1/2" steel cyclone operated at 9 liters/min. as a size selector. The filter media and analytical technique were the same as that defined above for the personal respirable samples.

D. Evaluation Criteria

1. Environmental Standards

The OSHA Standards for the substances evaluated are taken from Part 1910 of Title 29 of the Code of Federal Regulations, Section 1910.93, Tables G-1 and G-3, June 27, 1974.

Substance	8-hour time-weighted average* Concentration
Silica:	
Crystalline:	
Quartz (respirable)	$\frac{10\ mg/M^3}{\%\ SiO_2 + 2}$
Quartz (total dust)	$\frac{30\ mg/M^3}{\%\ SiO_2 + 2}$
Sulfur Dioxide	5 ppm
Iron Oxide Fume	10 mg/M^3
Carbon Monoxide	50 ppm

*For a pure free silica dust sample, % SiO_2 is 100, hence a standard of 0.1 mg/M^3 (100 $\mu g/M^3$) applies for the respirable fraction from the above equation. To allow a more direct comparison of personal sampling results to the present Federal Standard, the 100 $\mu g/M^3$ of respirable free silica as the Federal Standard has been shown in Table 3.

Other sources contain recommended occupational health standards that differ from the Federal Standards cited, the most notable exception concerns free silica exposure. The NIOSH Criteria Document[4] contains a recommendation for control of worker exposure to no greater than a time-weighted average of 50 micrograms/M^3 respirable free silica for up to a 10-hour work day, 40-hour work week for protection of worker health over a normal working lifetime. The NIOSH Criteria Document for carbon monoxide recommends that no worker be exposed to a concentration greater than 35 ppm as a time-weighted average exposure for an 8-hour workday.

2. Toxic effects of substances investigated[4,5,6,7,8]

The following discussion describes the toxicological effects that may occur in workers exposed to free silica, the major toxic substance to which workers were found to be exposed in this evaluation. These effects are described so workers will know the symptoms and health consequences of overexposure. The effects described depend upon a number of factors such as concentration, length of exposure, individual susceptibility, and possible synergistic effect of more than one substance.

Free Silica

The chief concern of excessive free silica exposure is the development of a condition termed silicosis. This form of pneumoconiosis usually occurs only after a number of years of exposure, although with severe exposure silicosis can occur in a short time. Early silicosis (termed "simple silicosis") is usually first diagnosed by chest x-ray examination. At this stage there is usually little if any functional impairment, and there are often no associated symptoms and signs. Symptoms occur when silicosis advances and becomes complicated by infection and emphysema.

The deposition of crystalline free silica in the lungs in sufficient amounts over a period of years may produce fibrous nodules. These nodules cause many individual alveoli (air sacs within lung) to be compressed and collapsed, thus reducing the function of the lungs. Continuous exposure to elevated concentrations of dust containing free silica may produce increased debilitating effects. These changes are marked by intolerance to exertion, episodes of coughing and production of thick purulent sputum. When silicosis has progressed to this point, the chest x-ray is usually read as "conglomerate silicosis". Conglomerate silicosis many times progresses in spite of termination of exposure and becomes incapacitating to affected workers.

E. Results and Discussion

April, 1974 Study

The results of personal samples with silica determinations are presented in Table I. The amount of free silica and the corresponding standard was determined for each sample. For the blast furnace workers one sample result was lower than the present Federal hygiene standard while the remaining three were above the standard with the highest result being more than four times the standard. Two workers were sampled in the stockhouse since the operator was training a helper on the day of the evaluation. These two results were 21 and 28 times greater than the Federal standard for free silica. Both of these samples also exceeded the Federal Standard for exposure to a nuisance dust which is 15 mg/M^3. One area sample was obtained in the cab of crane No. 250 and analyzed for total weight and silica. The weight gain of this filter was less than the minimum detectable limit of the weighing method and is therefore reported as a less than value. The result of this sample is less

than half the calculated standard for free silica. The Federal Standards were used for comparison to these environmental results of the initial study. At that time the primary criteria for evaluating total dust containing free silica was the Federal Standard, and four of six sample results were total dust samples.

A personal sample for the crane operator resulted in iron oxide exposure for this worker of 0.005 mg/M^3. Carbon monoxide could not be detected in the crane cab with the use of detector tubes. Maintenance workers were working in the vicinity of the No. 1 and No. 15 soaking pits on the day of evaluation. Carbon monoxide or sulfur dioxide could not be detected with the use of detector tubes in these areas; limits of detection for these methods are: Carbon monoxide - 10 ppm, sulfur dioxide - 1 ppm.

April - May, 1975 Study

A follow-up evaluation was conducted during the period of April 29-May 1, 1975 and involved obtaining area respirable particulate samples and personal respirable particulate samples in the stockhouse and cast floor areas. On May 1, 1975 the No. 3 Blast Furnace was down for repairs during the 7:30 a.m. to 3:30 p.m. and the 3:30 p.m. to 11:30 p.m. shifts. All other shifts sampled were normal blast furnace operations, two casts per shift at each furnace being the typical operation.

Area and personal samples were analyzed for free silica content by the x-ray diffraction analysis. Quartz was the only polymorph of free silica detected and results are therefore reported as µg of quartz and airborne concentrations of quartz in µg/M^3. The minimum detectable amount of quartz per filter was 10 µg with some samples reported as less than this value; results so reported are indicated as less than (<) values in Table 2 and Table 3 for both µg quartz and airborne concentrations of quartz. Area and personal sampling results were corrected by subtracting the average blank value of 1 µg per filter, obtained by ashing ten blank filters as one sample.

The results of area sampling in the cast floor and stockhouse areas of the plant are shown in Table 2. All of these results are below the present NIOSH recommendation for an environmental standard for free silica exposure although two results, both from the stockhouse area, show levels in excess of the NIOSH definition for exposure to free silica of 25 µg/M^3. In this evaluation area respirable dust results were not considered as indicative of free silica exposure as personal respirable samples. The area samples by necessity were collected in areas relatively remote from the actual work areas. It was particularly a problem on the cast floor since the cast process precluded locating sampling devices in the primary work areas where they would have created a potential tripping hazard to workers or could have been rendered inoperative by the intense heat of the cast process. The stockhouse area samples were located adjacent to the skip hole while the larry car is normally positioned here only when dropping a charge. Although area samples may provide useful information about general dust levels, they do not assess worker exposure as adequately as personal sampling devices which obtain samples from the workers' breathing zones.

A total of 39 personal respirable samples for cast floor workers and 19 personal respirable samples for stockhouse workers were collected during the April 29 - May 1, 1975 evaluation. The results of the personal respirable sampling are contained in Table 3. Five results are reported as less than (<) values in Table 3 although the absolute values would exceed the exposure to free silica level defined in the NIOSH Criteria Document and three would actually exceed the NIOSH Criteria Document Recommended Standard for free silica exposure. An explanation for either a detection limit greater than 10 ug per filter or a significantly reduced sampling time is contained in footnotes to Table 3. Since no interpretation can be placed on these five results as to whether or not they are either above or below the NIOSH Criteria Document definition of free silica exposure of 25 $\mu g/M^3$ or the recommended environmental standard of 50 $\mu g/M^3$, these five sample results were not considered in determining whether exposure to free silica was potentially toxic to workers in the cast floor or stockhouse areas. Upon elimination of these five results, there remains a total of 36 samples for cast floor workers and 17 samples for stockhouse workers which were considered interpretable for evaluating if a potentially toxic condition exists.

Cast Floor Workers

Seven of 36 samples (19%) were equal to or in excess of the NIOSH recommended environmental standard for free silica of 50 $\mu g/M^3$. The NIOSH Criteria Document defines "exposure to free silica" as an exposure of workers to airborne concentrations of free silica greater than half of the recommended environmental standard. Twelve results for cast floor blast furnace workers were less than the recommended environmental standard but greater than half the recommended environmental standard. Nineteen of 36 (53%) of the monitoring results for cast floor workers therefore were in excess of the Criteria Document definition for worker exposure to free silica. Where workers have exposure to free silica, the NIOSH recommended standard includes steps to: monitor workers medically, post warnings, use protective equipment, inform employees of hazards from free silica, institute work practice and control procedures, and monitor environmentally to protect worker health.

Stockhouse Workers

Seventeen personal respirable samples were collected for stockhouse-blast furnace workers with one result in excess of the recommended environmental standard. Additionally two sample results were below the recommended environmental standard but greater than half of the recommended environmental standard.

Conclusion

A significant proportion (19%) of the personal respirable sampling results in the cast floor area demonstrated an exposure to free silica in excess of the NIOSH recommended environmental standard of 50 $\mu g/M^3$ free silica and over half (53%) of these samples were found to be in excess of the

NIOSH Criteria Document definition of exposure to free silica (action level). One sample for stockhouse workers was in excess of the NIOSH recommended environmental standard and three (18%) were in excess of the action level.

Based upon the environmental evaluation of April 29 - May 1, 1975 and the NIOSH Criteria Document recommended environmental standard, it has been judged that cast floor workers were exposed to potentially toxic concentrations of respirable free silica. Although stockhouse workers are not normally exposed to excessive levels of free silica, on occasion the stockhouse blast furnace workers may be exposed to potentially toxic concentrations of respirable free silica. Appropriate recommendations for medical and environmental management are contained in Section V of this report pertaining to the cast floor blast furnace area.

V. RECOMMENDATIONS

Whenever feasible, engineering control is the preferred method of lowering environmental levels of toxic substances to protect workers from health hazards. The recommendations below are all of the type which may be implemented immediately while engineering controls are being provided to reduce employee exposures to less than 50 $\mu g/M^3$. These recommendations are based upon those contained in the NIOSH Criteria Document[4] concerning exposure to crystalline silica.

1. Medical

a. Medical examinations should be made available to cast floor workers prior to employee placement and at least once each three years thereafter. Examinations should include as a minimum:

(1) A medical and occupational history to elicit data on worker exposure to free silica and signs and symptoms of respiratory disease.

(2) A chest roentgenogram (posteroanterior 14" by 17" or 14" by 14") classified according to the 1971 ILO International Classification of Radiographs of Pneumoconioses. [ILO U/C International Classification of Radiographs of Pneumoconioses 1971, Occupational Safety and Health Series 22 (rev). Geneva, International Labor Office, 1972]

(3) Pulmonary function tests including forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1) to provide a baseline for evaluation of pulmonary function and to help determine the advisability of the workers using negative- or positive-pressure respirators. It should be noted that pulmonary function tests may vary significantly in various ethnic groups. For example, in black persons, the test values for the FVC should be divided by 0.85 before the percentage value is compared with normal figures.

(4) Body weight.

(5) Height.

(6) Age.

(7) Initial medical examinations for presently employed workers should be offered within 6 months.

b. Medical Management

An employee with or without roentgenographic evidence of silicosis who has respiratory distress and/or pulmonary functional impairment should be fully evaluated by a physician qualified to advise the employee whether he should continue working in a dusty trade.

c. Medical records should be maintained for at least 30 years following the employee's termination of employment.

2. Posting

a. Warnings should be posted at or near entrances of accessways to the cast floor blast furnace work areas to warn unauthorized persons to stay out of these areas.

b. Warnings should be posted in the cast floor blast furnace work areas warning personnel that these are free silica work areas and breathing the dust in these areas may cause delayed lung injury.

3. Respiratory Protection

a. Until environmental free silica levels have been reduced below the NIOSH recommended standard, respiratory protection should be provided to and used by exposed workers in the cast floor blast furnace areas. Respirators provided should be approved by NIOSH and have been approved to provide sufficient protection at the concentration of free silica occurring in the work area in which used.

b. A respiratory protective program meeting the requirements of Section 1910.134 of the Occupational Safety and Health Standards should be established and enforced by the employer.

4. Work Practices

Cast floor blast furnace workers should vacuum work clothing before removal. Clothes <u>should not</u> be cleaned by blowing or shaking.

5. Monitoring and Record Keeping

a. In all monitoring, samples representative of the exposure in the breathing zone of employees should be collected. An adequate number of samples should be collected to permit construction of a full-shift exposure for every operation or process. The Sampling Schedule below is a guide for determining the number of samples to be taken.

SAMPLING SCHEDULE

Number of Employees Exposed	Number of Time-weighted Average Determinations
1-20	50% of the total number of workers
21-100	10 plus 25% of the excess over 20 workers
over 100	30 plus 5% of the excess over 100 workers

b. Samples should be collected and analyzed at least every 6 months for the evaluation of the workers' exposure with respect to the NIOSH recommended standard.

c. Work environment (breathing zone) samples should be taken within 30 days after installation of a new process or process changes.

d. Records should be maintained of medical examinations and all sampling schedules to include the sampling and analytical methods, type of personal protection devices, if any, in use at the time of sampling and the determined free silica dust concentration. Records should be maintained for at least 30 years following termination of workers' employment. Each employee should be able to obtain information on his exposure.

VI. REFERENCES

1. General Procedure for Metals by Atomic Absorption, P & CAM 173, Physical and Chemical Analysis Branch, NIOSH, CDC, PHS, U.S. DHEW, HEW Publ. No. (NIOSH) 75-121.

2. Colorimetric Method for Free Silica, P & CAM 106, Physical and Chemical Analysis Branch, NIOSH, CDC, PHS, U.S. DHEW, HEW Publ. No. (NIOSH) 75-121.

3. Free Silica (Quartz, Cristobalite, Tridymite) in Atmosphere Dust, P & CAM 109, Physical and Chemical Analysis Branch, NIOSH, CDC, PHS, U.S. DHEW, HEW Publ. (NIOSH) 75-121.

4. Criteria for a recommended standard... Occupational Exposure to Crystalline Silica, NIOSH, CDC, PHS, DHEW, HEW Publication No. (NIOSH) 75-120, 1974.

5. Documentation of the Threshold Limit Values, ACGIH, 3rd Ed., Cincinnati, Ohio, 1971.

6. Hygiene Guide Series, ACGIH, 14125 Prevast, Detroit, Michigan.

7. Patty, F. A., Industrial Hygiene and Toxicology, Second Revised Edition, Vol. II, Interscience Publishers, New York, 1967.

8. Encyclopedia of Occupational Health and Safety, International Labor Office, McGraw-Hill Book Co., New York, 1971

VII. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:

Robert E. Rosensteel
Industrial Hygienist
Hazard Evaluation Services Branch
Cincinnati, Ohio

Originating Office:

Jerome P. Flesch
Chief
Hazard Evaluation Services Branch
Cincinnati, Ohio

ACKNOWLEDGMENTS

Environmental Evaluation:

Raymond Ruhe
Industrial Hygienist
Hazard Evaluation Services Branch

Jerome P. Flesch, Chief
Hazard Evaluation Services Branch

Raymond O. Rivera
Industrial Hygienist
Hazard Evaluation Services Branch

Laboratory Analyses:

Wayne Smallwood
Chemist
Physical and Chemical Analysis Branch
Cincinnati, Ohio

TABLE 1

Results of Personal Sampling for Airborne Free Silica in Blast Furnace and Stockhouse Areas-April 25, 1974*

JOB DESCRIPTION	SAMPLE WEIGHT GAIN (mg)	LENGTH OF SAMPLE (minutes)	FREE** SILICA (%)	CALCULATED FEDERAL STANDARD (mg/M^3)	SAMPLE CONCENTRATION (mg/M^3)	RATIO $\frac{\text{Sample}}{\text{Standard}}$	TYPE SAMPLE
Cinder Keeper	1.23	381	3.5	1.8	1.9	1.1	Respirable
1st Helper	4.08	377	12.4	2.1	7.2	3.4	Total
2nd Helper	0.81	377	1.4	2.9	1.3	0.4	Respirable
3rd Helper	4.40	369	15.9	1.7	7.9	4.6	Total
Larry Car Operator	42.6	367	9.0	2.7	77.3	28.6	Total
Larry Car Helper	19.6	362	15.7	1.7	36.1	21.2	Total
General Area Crane #230	<.51	377	12.4	2.1	<.90	<0.4	Total

*Respirable samples may be compared to the NIOSH Criteria Document Standard of 50 $\mu g/M^3$. Results of this comparison are:

	Sample Concentration	Ratio - $\frac{\text{Sample}}{\text{Standard}}$
Cinder Keeper	66 $\mu g/M^3$	1.3
2nd Helper	17 $\mu g/M^3$	0.34

**Corrected for free silica content of filter blanks.

Table 2

RESULTS OF AREA SAMPLING FOR RESPIRABLE FREE SILICA IN BLAST FURNACE AND STOCKHOUSE AREAS
(April 29 - May 1, 1975)

Date	Shift	Location	Sample Time (min.)	µg Quartz	Quartz Dust Con. ($\mu g/M^3$)
4/29	7:30am- 3:30pm	#5 BF - Cast Floor	316	59	21
4/29	7:30am- 3:30pm	#3 BF - Cast Floor	335	<40	<13
4/30	7:30am- 3:30pm	#3 BF - Cast Floor	353	<30	<10
4/30	7:30am- 3:30pm	#5 BF - Cast Floor	363	25	8
4/30	7:30am- 3:30pm	#5 BF - Stockhouse	357	89	28
4/30	3:30pm-11:30pm	#3 BF - Cast Floor	372	<50	<15
4/30	3:30pm-11:30pm	#5 BF - Cast Floor	415	<50	<13
4/30	3:30pm-11:30pm	#5 BF - Stockhouse	409	<30	< 8
5/1	7:30am- 3:30pm	#3 BF - Cast Floor	459	49	12
5/1	7:30am- 3:30pm	#5 BF - Cast Floor	458	99	24
5/1	7:30am- 3:30pm	#5 BF - Stockhouse	443	169	42
5/1	3:30pm-11:30pm	#3 BF - Cast Floor	334	69	23
5/1	3:30pm-11:30pm	#5 BF - Cast Floor	347	25	8
5/1	3:30pm-11:30pm	#5 BF - Stockhouse	385	59	17

All samples collected using 1/2" steel cyclone size selector w/FWSB Filters held in 3-piece cassette at a flowrate of 9 lpm.

Table 3

RESULTS OF PERSONAL SAMPLING
FOR RESPIRABLE FREE SILICA IN BLAST FURNACE AREAS
(April 29 - May 1, 1975)

Date	Shift	Location	Job Description	Sample Time (min.)	µg Quartz	Quartz Dust Conc. (µg/M3)
4/29	7:30am- 3:30pm	Blast Furnace #3	Keeper	407	9	14
			1st Helper	408	29	42
			2nd Helper	399	19	29
			3rd Helper	399	49	72
			Larry Car Op.	388	19	29
			Larry Car Helper	362	<10	<16
		Blast Furnace #5	Keeper	395	34	50
			1st Helper	376	29	44
			2nd Helper	371	39	62
			3rd Helper	381	29	45
			Larry Car Op.	377	49	71
			Larry Car Helper	357	<10	<16
4/30	7:30am- 3:30pm	Blast Furnace #3	Keeper	419	<10	<14
			1st Helper	427	29	40
			2nd Helper	428	29	40
			3rd Helper	398	39	58
			Larry Car Op.	419	<10	<14
			Larry Car Helper		14	20
		Blast Furnace #5	Keeper	404	<10	<15
			1st Helper	417	24	34
			2nd Helper	418	29	41
			3rd Helper	414	19	27
			Larry Car Op.	417	<10	<14
			Larry Car Helper	414	<10	<14
4/30	3:30pm-11:30pm	Blast Furnace #3	Keeper	444	9	12
			1st Helper	394	29	43
			2nd Helper	391	19	29
			3rd Helper	399	9	13
			Larry Car Op.	409	<10	<14
			Larry Car Helper	374	<10	<16
		Blast Furnace #5	Keeper	415	<10	<14
			1st Helper	423	9	13
			2nd Helper	417	9	13
			3rd Helper	419	<10	<14
			Larry Car Op.	408	<10	<14
			Larry Car Helper	371	<10	<16
5/1	7:30am- 3:30pm	Blast Furnace #3	Keeper	384	44	67
			1st Helper	363	94	152
			2nd Helper	189	<10	<31(1)
			3rd Helper	272	14	30
			Larry Car Op.	400	<10	<15
			Larry Car Helper	408	<50	<72(2)
		Blast Furnace #5	Keeper	422	<10	<14
			1st Helper	416	44	62
			3rd Helper	413	<40	<57(2)
			Larry Car Op.	414	19	27
			Larry Car Helper	408	<10	<15
5/1	3:30pm-11:30pm	Blast Furnace #3	Keeper	333	<50	<88(2)
			1st Helper	278	9	19
			2nd Helper	277	<10	<21
			3rd Helper	283	<10	<21
			Larry Car Helper	326	<10	<18
		Blast Furnace #5	Keeper	422	9	13
			1st Helper	434	19	26
			2nd Helper	417	<10	<14
			Utility	372	<10	<16
			Larry Car Op.	397	<20	<30(2)
			Larry Car Helper	394	<10	<15
NIOSH Recommended Standard						50
Federal Standard as pure respirable quartz						100

(1) Left work before end of shift resulting in a reduced sample time.
(2) Increased detection limits for these samples due to interferences with the x-ray diffraction analysis.